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TLI SHIP POSITIONING AND COVERAGE
DATA FOR MISSION G (APOLLO 11)
LUNAR LAUNCH OPPORTUNITIES
FOR JULY, AUGUST, AND
SEPTEMBER 1969

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Lunar Mission Analysis Branch
MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS



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PROJECT APOLLO

TLI SHIP POSITIONING AND COVERAGE DATA FOR MISSION G
(APOLLO 11) LUNAR LAUNCH OPPORTUNITIES FOR
JULY, AUGUST, AND SEPTEMBER 1969

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May 23, 1969

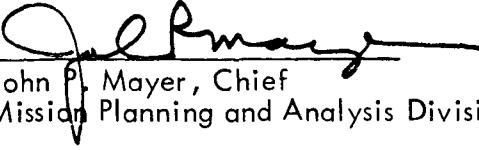
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FOREWORD

The spacecraft operational trajectory for Mission G is composed of five volumes which summarize the lunar landing missions for a 3-month launch period, July, August, and September. The contents of each volume are briefly described below.

1. Volume I - Operational Mission Profile, Launched July 16, 1969: Detailed mission description of the first launch opportunity, first injection opportunity, of the July launch window. MSC IN 69-FM-98.

2. Volume II - Operational Mission Profile Trajectory Parameters, Launched July 16, 1969: Listing of significant trajectory parameters computed at selected time points during each phase of the same typical mission described in Volume I. MSC IN 69-FM-99.

3. Volume III - Mission Summaries: July 1969 Launch Window: Summaries of CSM trajectory parameters at selected time points for each launch date in the July 1969 launch window. MSC IN 69-FM-100.

4. Volume IV - Mission Summaries: August 1969 Launch Window: Summaries of CSM trajectory parameters at selected time points for each launch date in the August 1969 window. MSC IN 69-FM-101.

5. Volume V - Mission Summaries: September 1969 Launch Window: Summaries of CSM trajectory parameters at selected time points for each launch date in the September 1969 window. MSC IN 69-FM-102.

In addition to the five volumes of the operational trajectory described above, six additional documents supplement the operational trajectory.

6. Hybrid Operational Mission Profile, Launched September 13, 1969: Detailed mission description for a typical hybrid mission profile. MSC IN 69-FM-111.

7. Hybrid Operational Mission Profile Trajectory Parameters, Launched September 13, 1969: Same trajectory parameter data as Volume II except compiled from the hybrid mission. MSC IN 69-FM-112.

8. Preliminary Lunar Orbit Attitude Sequence: CSM and LM attitude sequence of events for the lunar orbit phase of the mission. MSC IN 69-FM-103. A more detailed attitude sequence for the entire mission will follow the preliminary document by 1 month.

9. TLI Ship Position and Coverage Data, July, August, and September 1969 Launch Opportunities: Injection ship positions and the launch azimuth range coverage for each day for both injection opportunities. MSC IN 69-FM-104.

10. Flight Crew Simulator Data: Provides data to satisfy flight crew and flight controller training and simulation requirements. MSC IN 69-FM-105.

11. Operational Trajectory Consumables Analysis: Prediction of the consumables usage and margins. MSC IN 69-FM-106.

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TLI SHIP POSITIONING AND COVERAGE DATA FOR MISSION G

(APOLLO 11) LUNAR LAUNCH OPPORTUNITIES FOR

JULY, AUGUST, AND SEPTEMBER 1969

By B. A. Brewer
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Mission Design Section
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1. INTRODUCTION AND SUMMARY

Injection ship positioning and coverage data are presented for Apollo mission 11 lunar launch opportunities occurring during July 1969, August 1969, and September 1969. The injection ships are positioned to provide coverage from TLI ignition minus 2 minutes to TLI ignition. These data were determined using the visual technique presented in Reference 1 and verified using the radar ship tracking program described in Reference 2. The positions of the TLI maneuvers were obtained from Reference 3.

Launch days specified for analysis were July 16, 18, and 21, August 14, 16, and 20, and September 13, 15, and 18. Coverage was examined for all launch azimuths from 72 through 108 degrees. The coverage was determined for both first and second injection opportunities. A plan was derived that specifies daily ship positions for the days chosen for the July, August, and September opportunities.

For the July opportunity, in order to provide coverage for the opening of the window on July 21, ship 2 is positioned so that it does not provide coverage on July 16. For the August opportunity, ship 2 is positioned to provide coverage of the opening of the window on August 20. This ship remains at the same position for the entire August opportunity. It does not provide coverage for August 14 and 16.

Both the Guam and Hawaii MSFN stations provide supplemental coverage dependent upon the TLI maneuver loci.

The coverage provided by the reentry ship is a continuation of the coverage provided by the injection ships, Guam, or Hawaii, whenever possible. The support positions specified for the reentry ship are such that repositioning to cover the reentry occurring approximately 170 hours later is within the ship's movement capability.

2. SHIP POSITIONING GUIDELINES

The general guidelines established to determine the ship positions and coverage data presented in this report are as follows:

1. Coverage is optimized for the final 2 minutes of the S-IVB preignition sequence (TLI ignition minus 2 minutes to TLI ignition).
2. Coverage begins at the opening of the window whenever possible and is continuous across the maximum possible number of launch azimuths.
3. Coverage is maximum for the first injection opportunity.
4. Coverage is provided for the complete 36-degree launch window when possible.
5. The movement rate of the injection ships Mercury and Redstone and the reentry ship Huntsville is limited to a speed of advance (SOA) of 12 knots for repositioning on a day-to-day basis.
6. The movement rate of the ships while in restricted waters is limited to a SOA of 10 knots.
7. The support positions for the first and second days of the opportunity may be separated by 21 hours of movement time; however, 24 hours of movement time may separate the support positions for subsequent days.
8. The minimum depth of the water in which the ships are able to maneuver is 5 fathoms.
9. The minimum antenna elevation angle is assumed to be 0 degree.
10. The reentry ship is positioned to provide TLI maneuver burn coverage for lower launch azimuths.
11. The reentry ship is positioned to provide additional support by overlapping with Guam, Hawaii, or TLI ships whenever possible.
12. The reentry ship must be positioned to be able to return to the entry position for each launch date 170 hours after TLI.

3. RESULTS

The support positions of the ships and the coverage which is provided by the injection ships from TLI ignition minus 2 minutes to TLI ignition are shown in Tables I, II, and III. The coverage data are shown on bar graphs in terms of the launch azimuths for each launch date. Coverage for the first and second injection opportunities is given, and the launch azimuths common to both opportunities for which coverage is provided are identified. Coverage data and the duration of the launch window for which coverage is provided along with the corresponding ship positions for each launch day are presented in tabular form below the bar graphs.

Maps showing the TLI and TLI minus 2-minute maneuver loci for the first injection opportunity and the locations of the ships on each day of July, August, and September are presented in Figures 1, 2, and 3. The July TLI maneuvers range from near 4° South latitude on July 16 to about 22° North latitude on July 21. The August TLI maneuvers range from 6° North latitude on August 14 to near 30° North latitude on August 20. The September TLI maneuvers range from near 20° North latitude on September 13 to about 28° North latitude on September 15.

MSFN and injection ship visibility contours are presented in Figures 4 through 7. The spacecraft positions at TLI and TLI minus 2 minutes are indicated for both the first and second injection opportunities. Coverage is shown as a function of launch azimuths versus ground elapsed time.

The coverage from the two injection ships is generally good for the entire window. The opening of the window is provided coverage for each day under consideration. Ship movement capabilities limit the coverage of the launch window on July 16, August 14, and August 16. One ship does not provide any coverage for these days.

The Guam and Hawaii MSFN stations provide some coverage for each of the months.

The duration of the launch window for which coverage of the first injection opportunity is provided ranges from less than 1 hour on July 16 to near 2.5 hours on July 21. The duration of the launch window in August ranges from about 1.5 hours on August 14 to more than 4 hours on August 20. In September, the duration of the launch window ranges from more than 3 hours on September 13 to more than 4.5 hours on September 15.

Table I. Practical Ship Positions and Tracking Coverage from TLI Ignition Minus 2 Minutes Through TLI Ignition; Mission Opportunities for July 16, 18, and 21, 1969



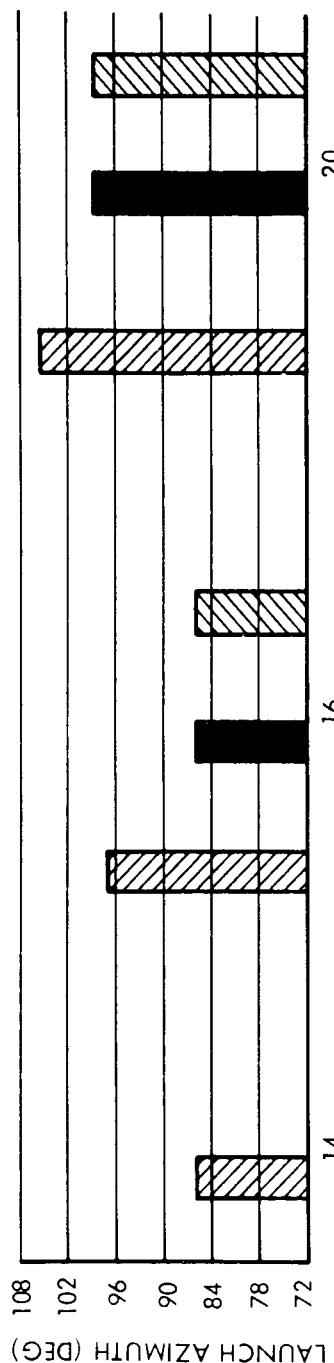
LAUNCH AZIMUTH COVERAGE PROVIDED BY INJECTION SHIPS AND MSFN STATIONS

■ (SECOND REVOLUTION) ■ (COMMON) ■ (THIRD REVOLUTION)

SHIP POSITIONS

Azimuths Covered (deg)	Launch Window Duration For Azimuths Covered (hr:min)			Injection Ships		Reentry Ship	
			Second Rev	Common	Third Rev	Ship 1	Ship 2
	Lat (deg)	Long (deg)	Lat (deg)	Long (deg)	Lat (deg)	Long (deg)	Lat (deg)
JULY 16	72-79	-	-	-	0:47	-	-
JULY 18	72-90	72-78	72-78	2:01	0:34	0:34	2.25S 166.8E 10.0N 175.2W 3.0N 154E
JULY 21	72-96	72-86	72-86	2:23	0:54	0:54	4.0N 172.0E 15.0N 166.5W 10.0N 157E
					11.5N	177.5W	16.5N 151W 12.0N 166E

Table II. Practical Ship Positions and Tracking Coverage from TLI Ignition Minus 2 Minutes Through TLI Ignition; Mission Opportunities for August 14, 16, and 20, 1959



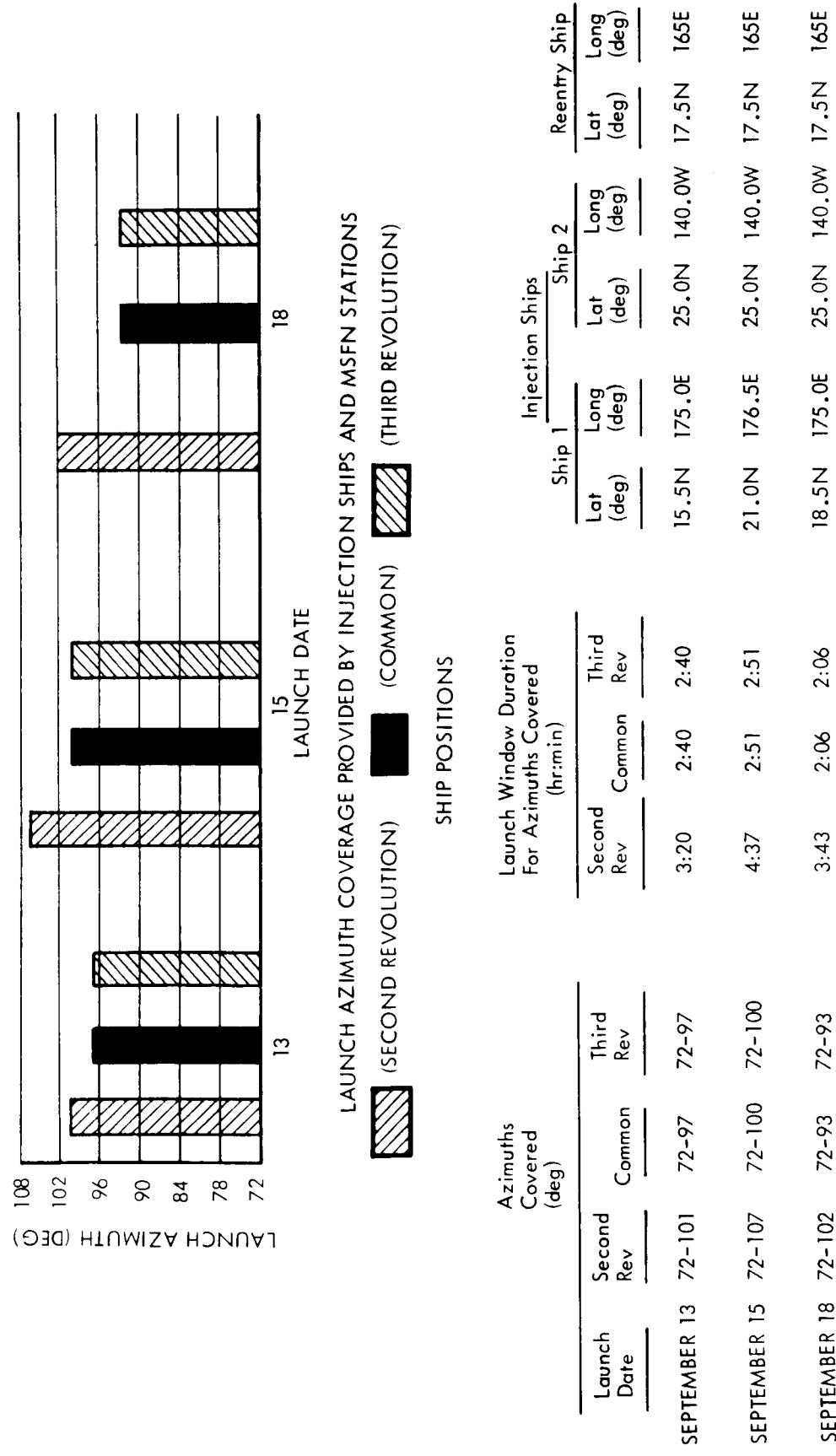
LAUNCH AZIMUTH COVERAGE PROVIDED BY INJECTION SHIPS AND MSFN STATIONS

■ (SECOND REVOLUTION) ■ (COMMON) ■ (THIRD REVOLUTION)

SHIP POSITIONS

Launch Date	Azimuths Covered (deg)			Launch Window Duration For Azimuths Covered (hr:min)			Injection Ships			Reentry Ship			
	Second Rev		Common	Third Rev		Ship 1	Ship 2		Lat (deg)		Lat (deg)	Long (deg)	
	Second Rev	Common	Rev	Third Rev	Rev	Lat (deg)	Long (deg)	Lat (deg)	Long (deg)	Lat (deg)	Long (deg)	Lat (deg)	
AUGUST 14	72-86	-	-	-	-	1:33	-	-	-	7.5N	179E	25.0N	140.0W
AUGUST 16	72-97	72-86	72-86	2:47	1:15	1:15	12.0N	177.5E	25.0N	140.0W	15N	161E	
AUGUST 20	72-106	72-99	72-99	4:20	2:40	2:40	19.5N	178.0E	25.0N	140.0W	15N	161E	

Table III. Practical Ship Positions and Tracking Coverage from TLI Ignition Minus 2 Minutes Through TLI Ignition; Mission Opportunities for September 13, 15, and 18, 1969



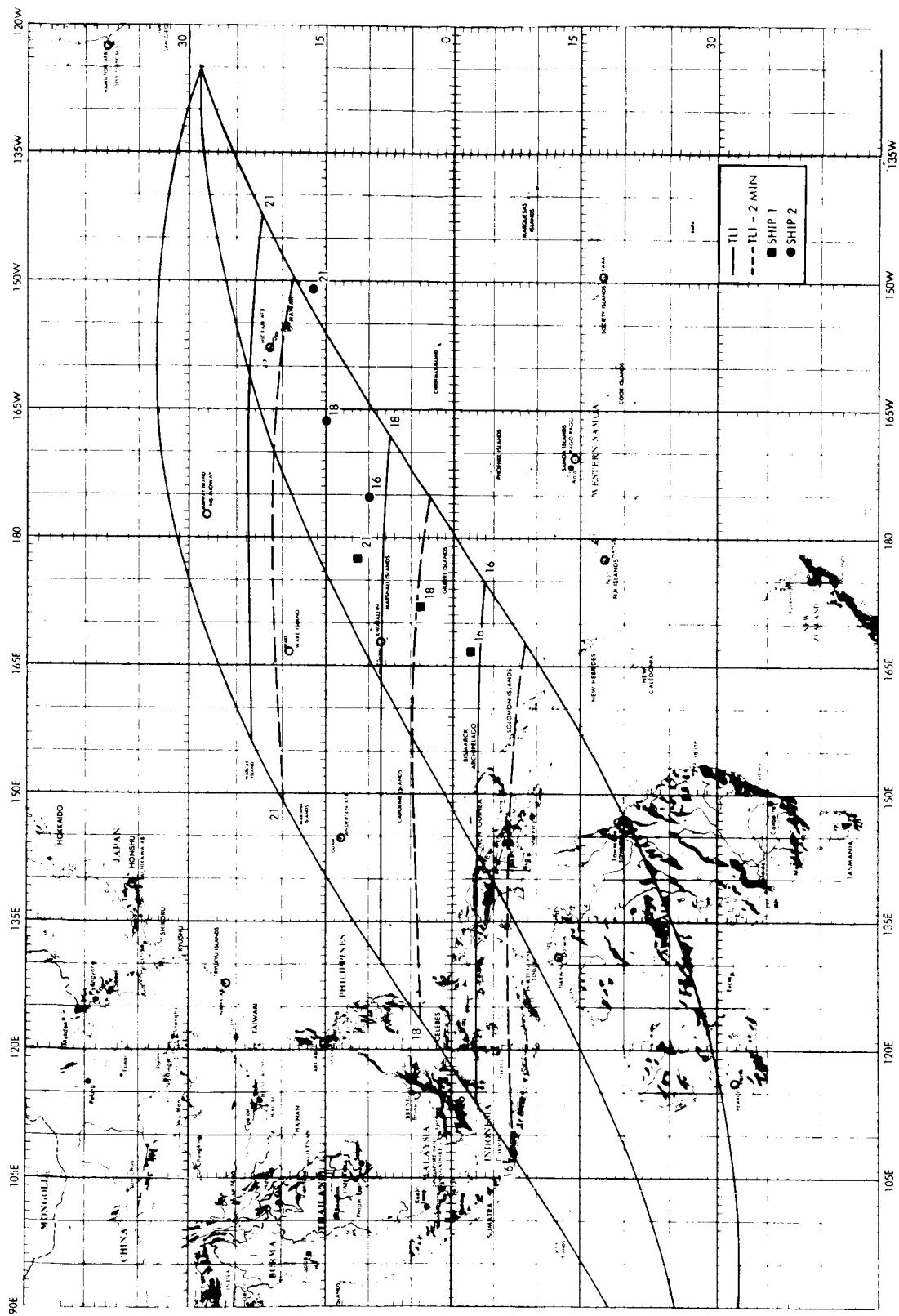


Figure 1. TLI Maneuver Loci and Practical Ship Positions for Tracking Coverage from TLI Ignition Minus 2 Minutes Through TLI Ignition for Day-to-Day Ship Repositioning Criteria: Mission Opportunities for July 16, 18, and 21, 1969

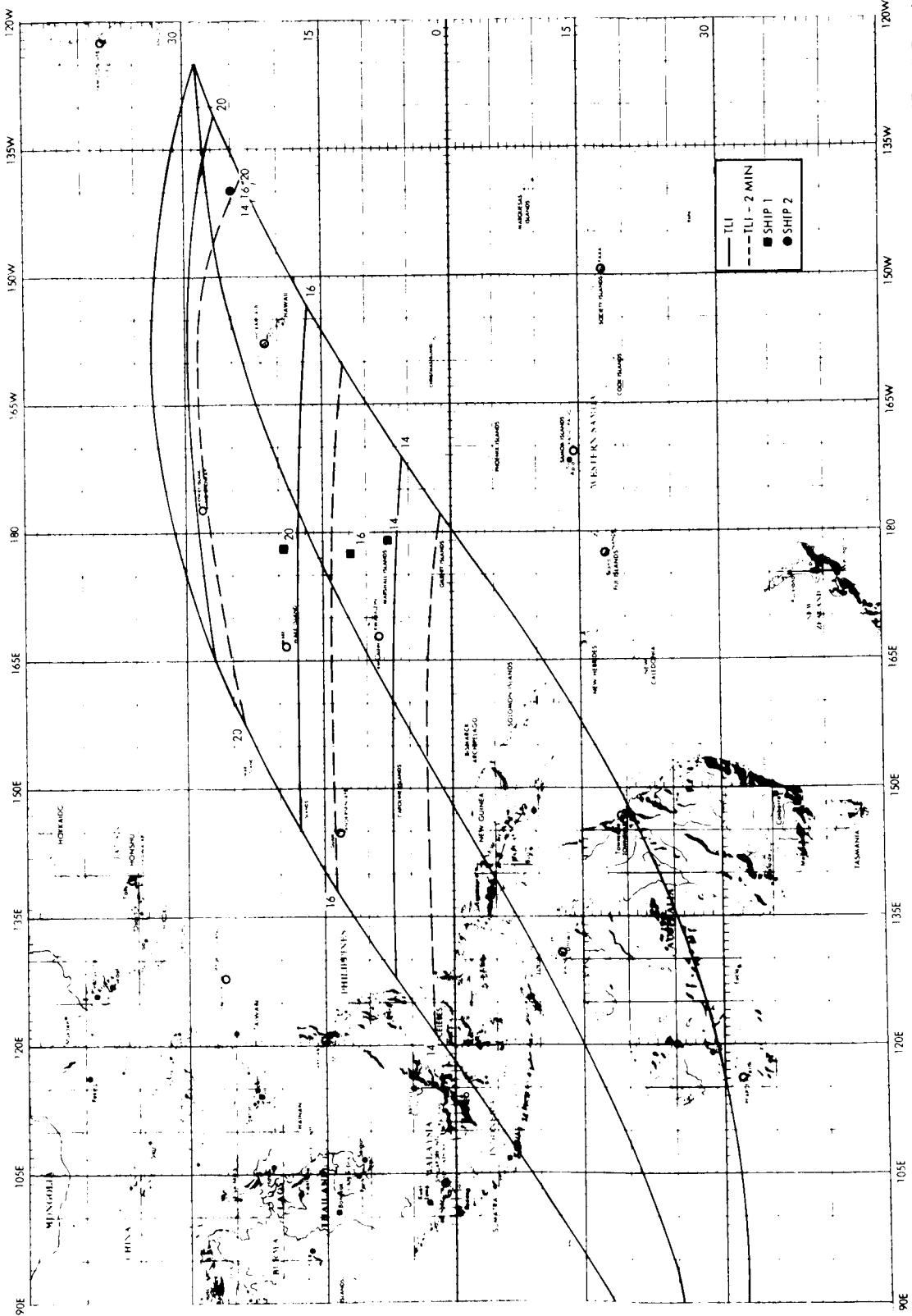


Figure 2. TLI Maneuver Loci and Practical Ship Positions for Tracking Coverage from TLI Ignition Minus 2 Minutes Through TLI Ignition for Day-to-Day Ship Repositioning Criteria: Mission Opportunities for August 14, 16, and 20, 1969

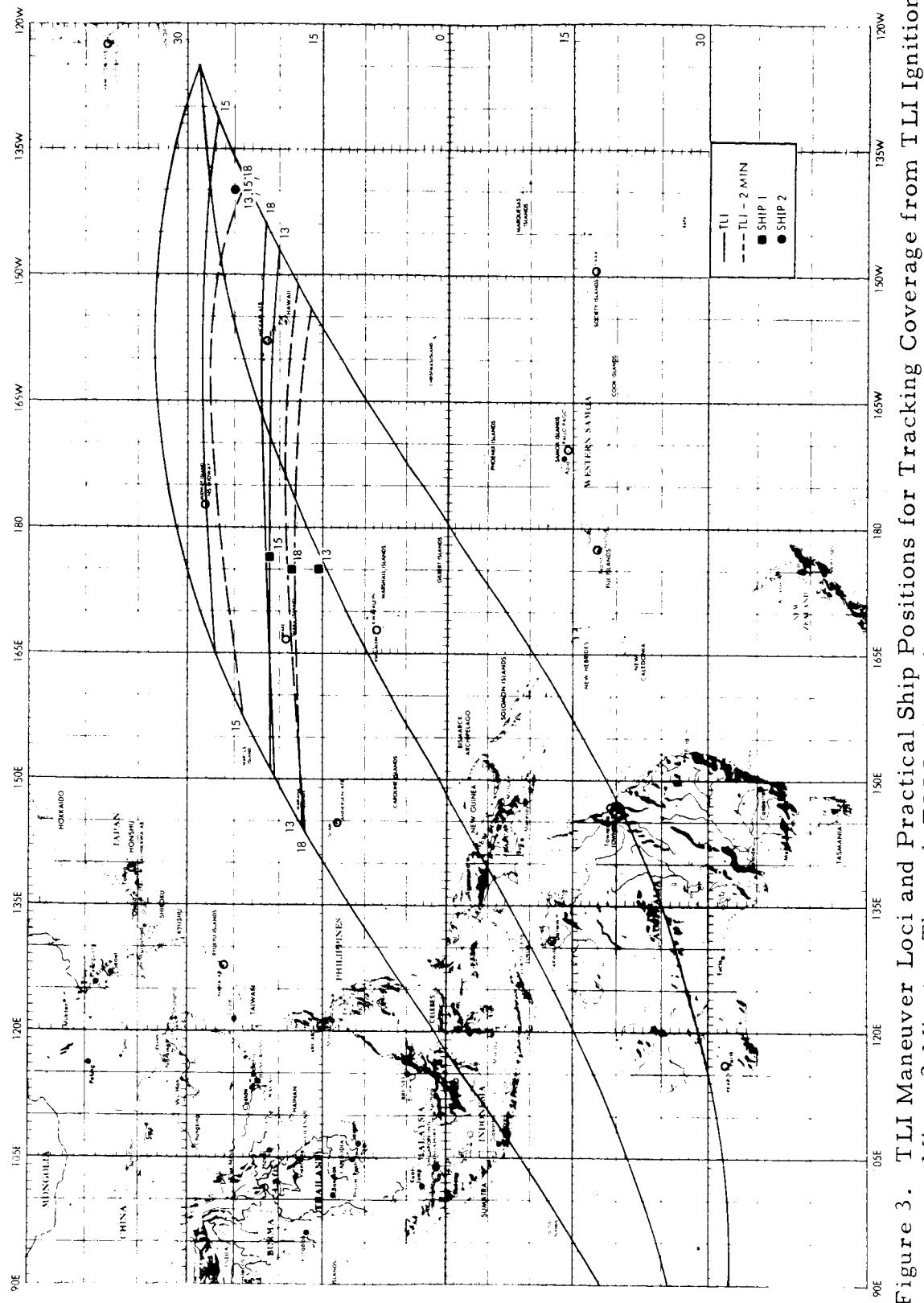


Figure 3. TLI Maneuver Loci and Practical Ship Positions for Tracking Coverage from TLI Ignition Minus 2 Minutes Through TLI Ignition for Day-to-Day Ship Repositioning Criteria: Mission Opportunities for September 13, 15, and 18, 1969

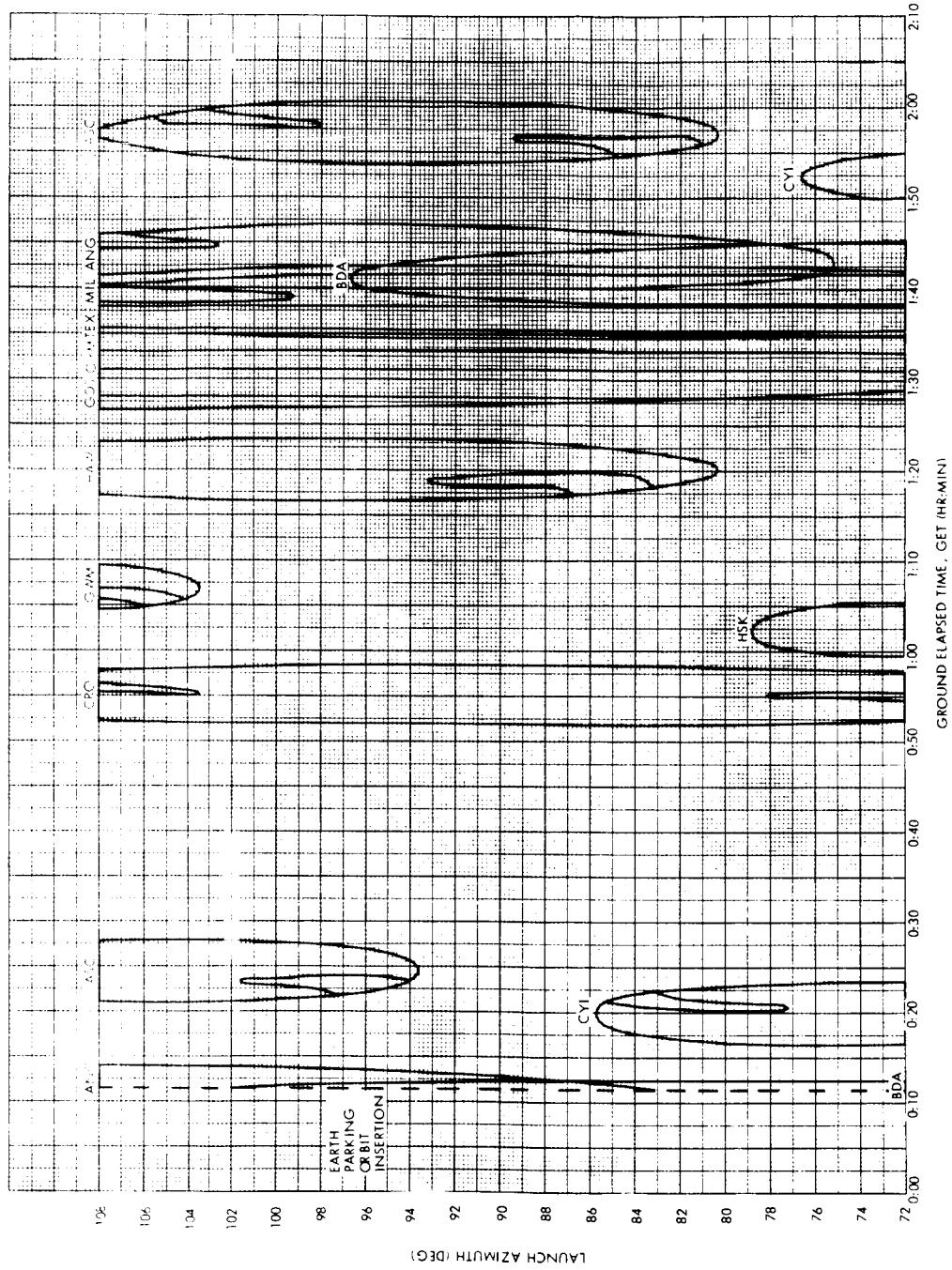


Figure 4. MuSIF visibility Contours, 0-degree Antenna Elevation,
Lift-off to Lift-off + 2:10 hr:min

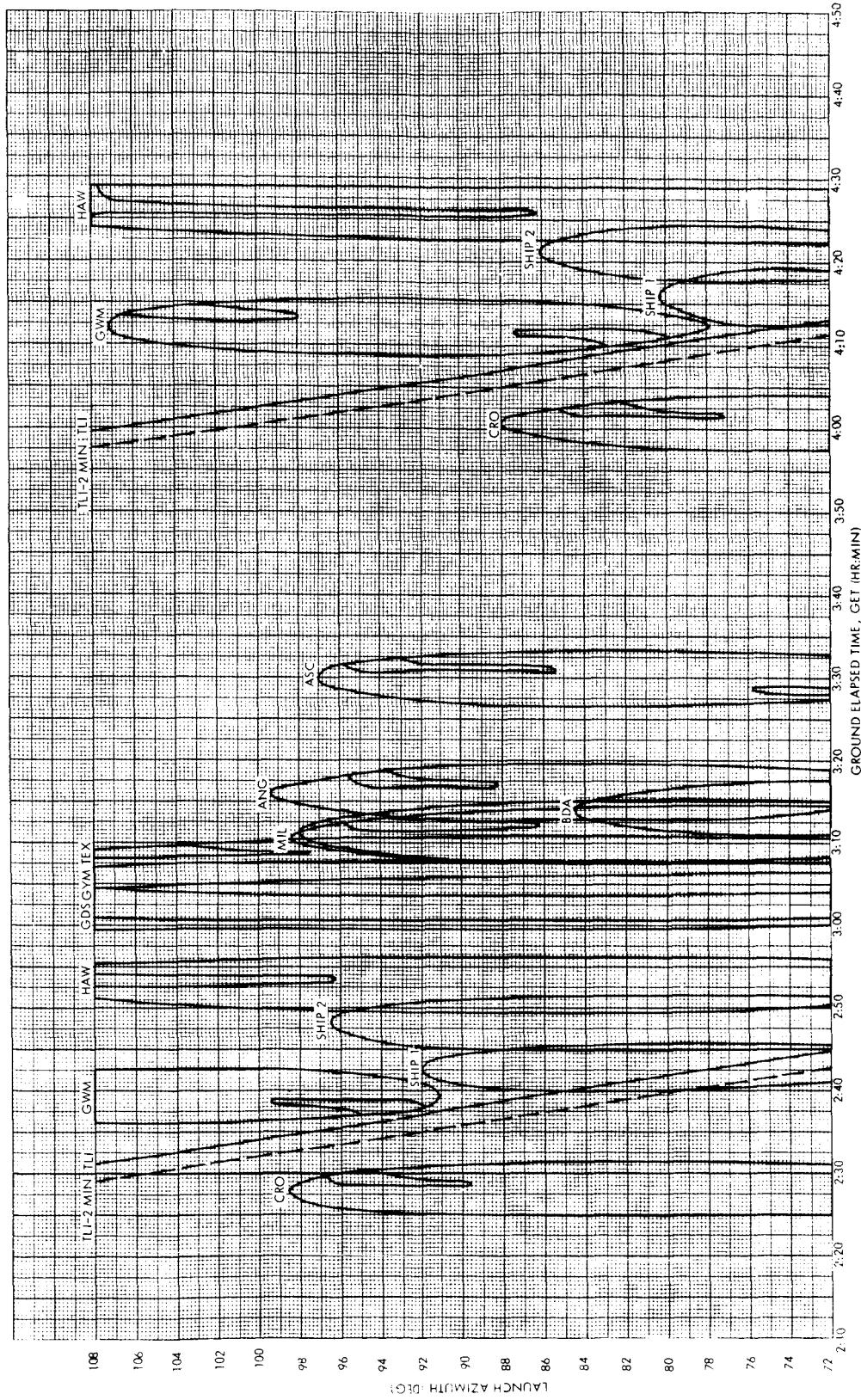


Figure 5a. MSFN and Injection Ships Visibility Contours, 0-degree Antenna Elevation,
July 16, 1969

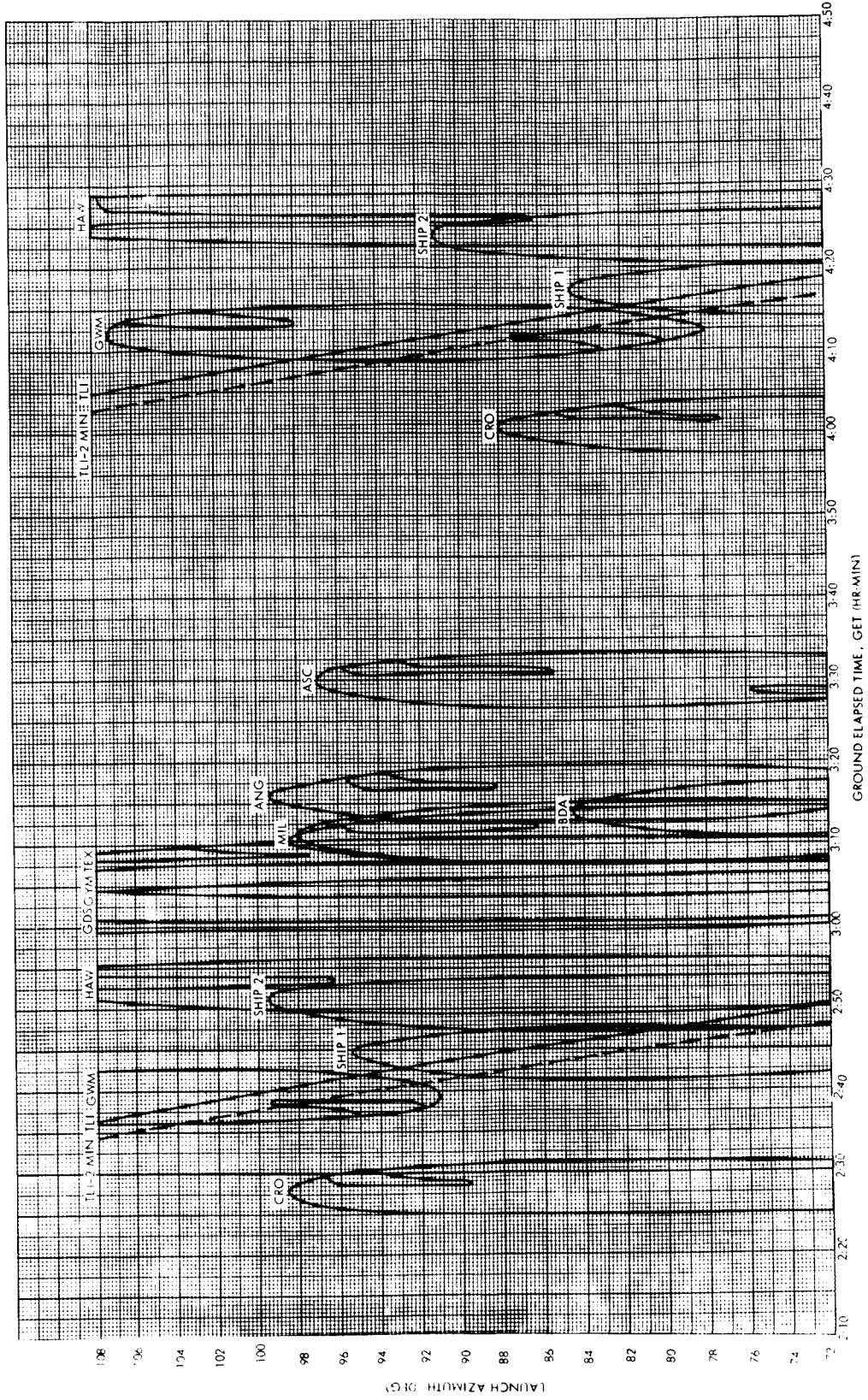


Figure 5b. MSFN and Injection Ships Visibility Contours, 0-degree Antenna Elevation,
July 18, 1969

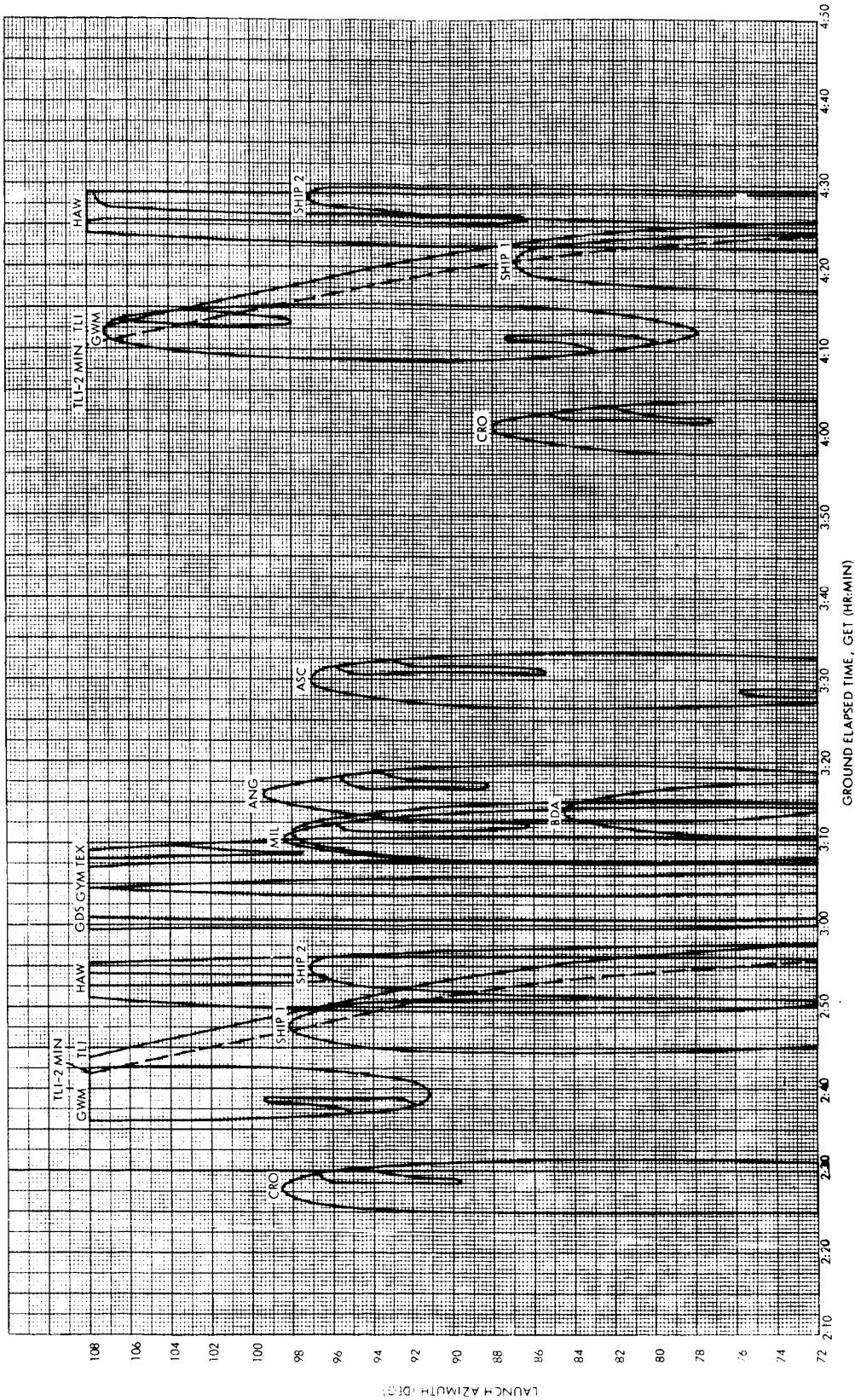


Figure 5c. MSFN and Injection Ships Visibility Contours, 0-degree Antenna Elevation,
July 21, 1969

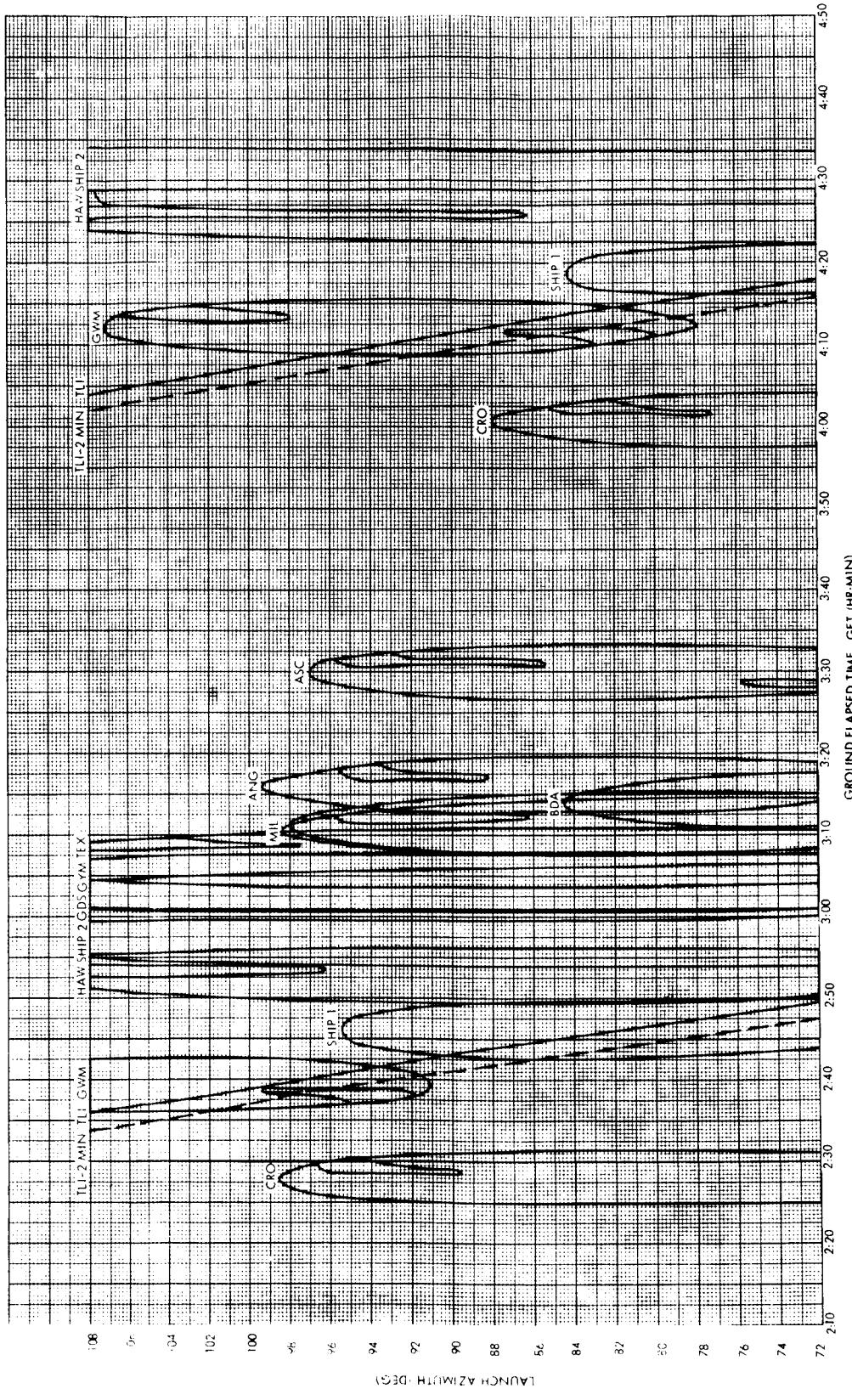


Figure 6a. MSFN and Injection Ships Visibility Contours, 0-degree Antenna Elevation,
August 14, 1969

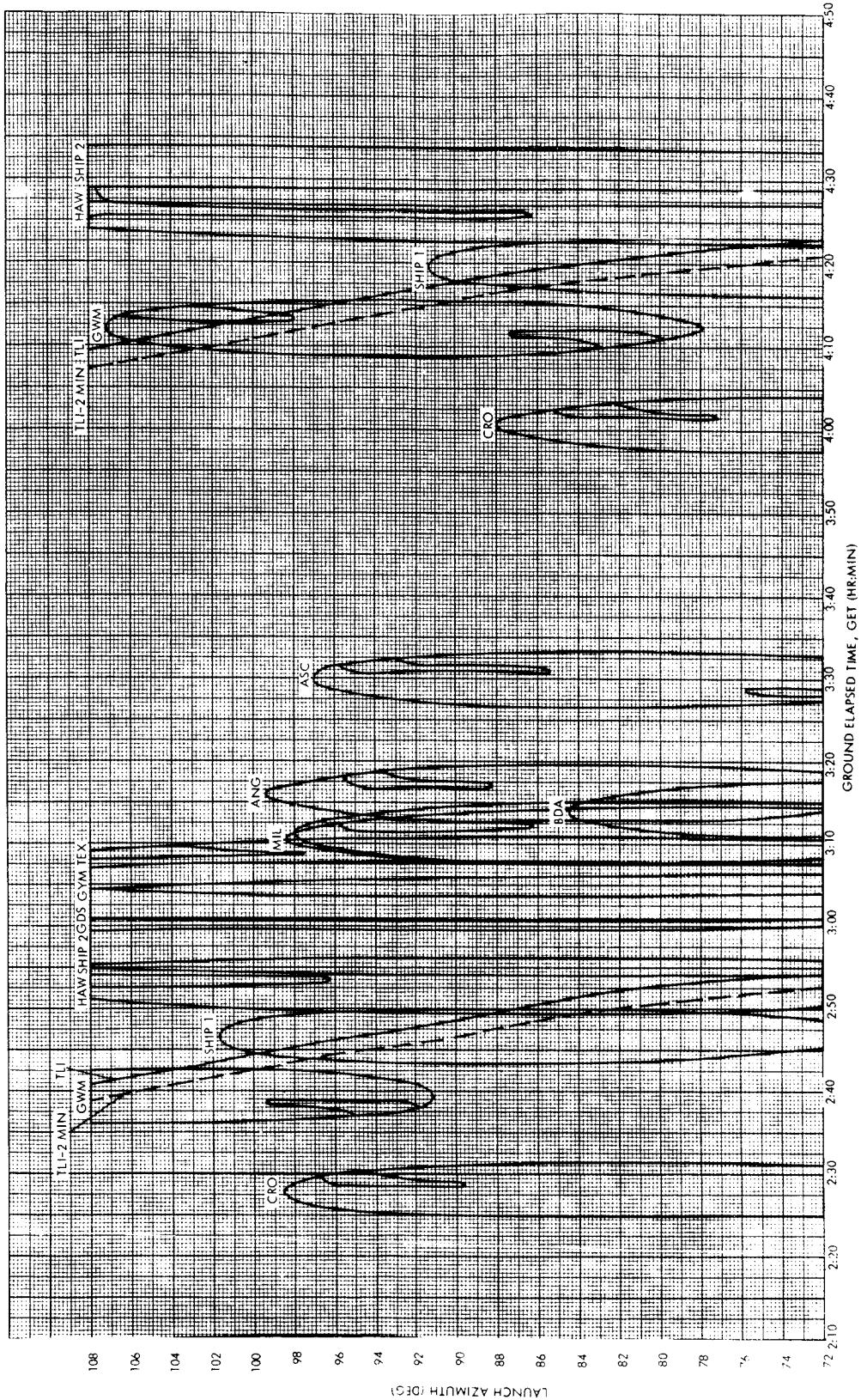


Figure 6b. MSFN and Injection Ships Visibility Contours, 0-degree Antenna Elevation,
August 16, 1969

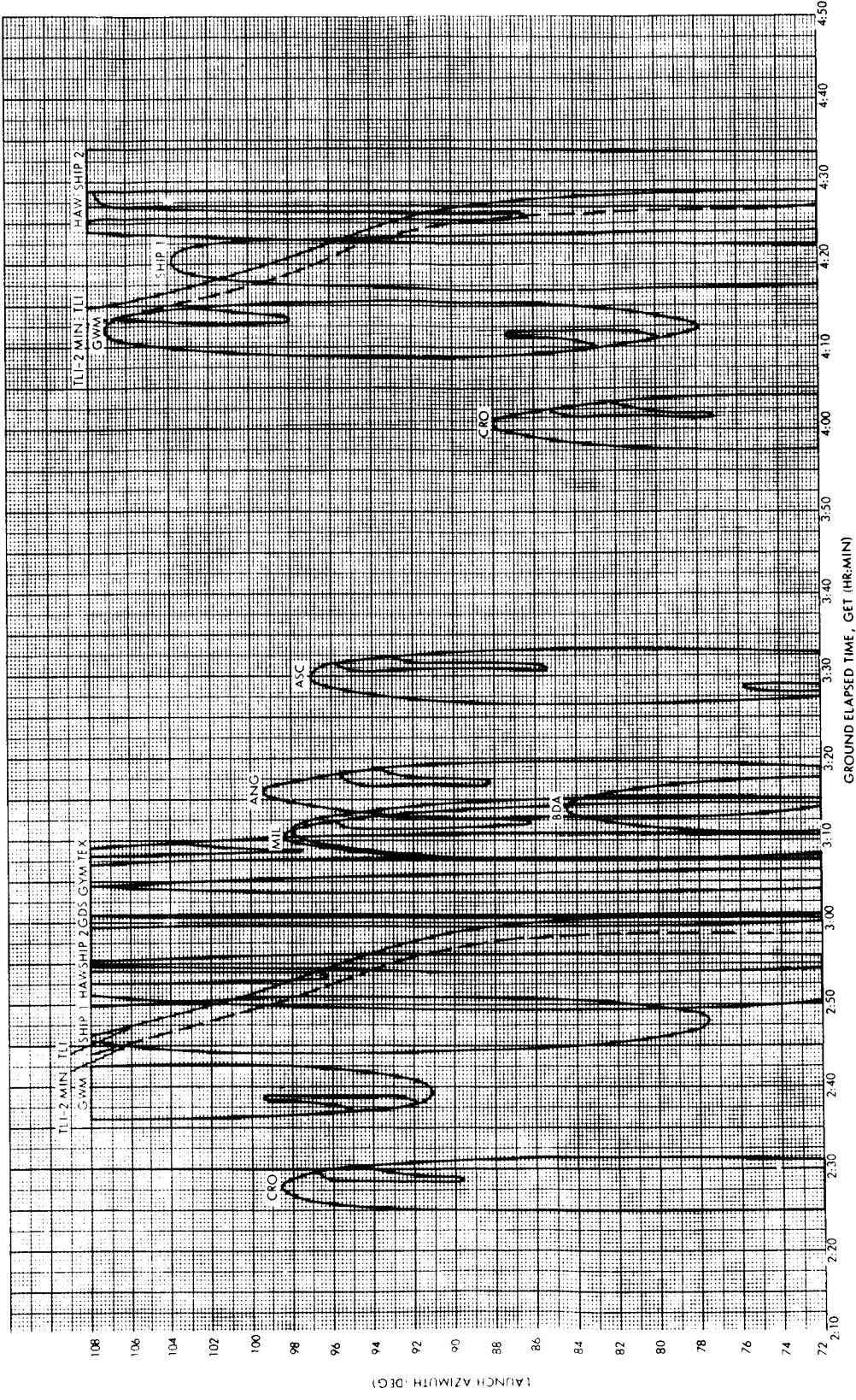


Figure 6c. MSFN and Injection Ships Visibility Contours, 0-degree Antenna Elevation,
August 20, 1969

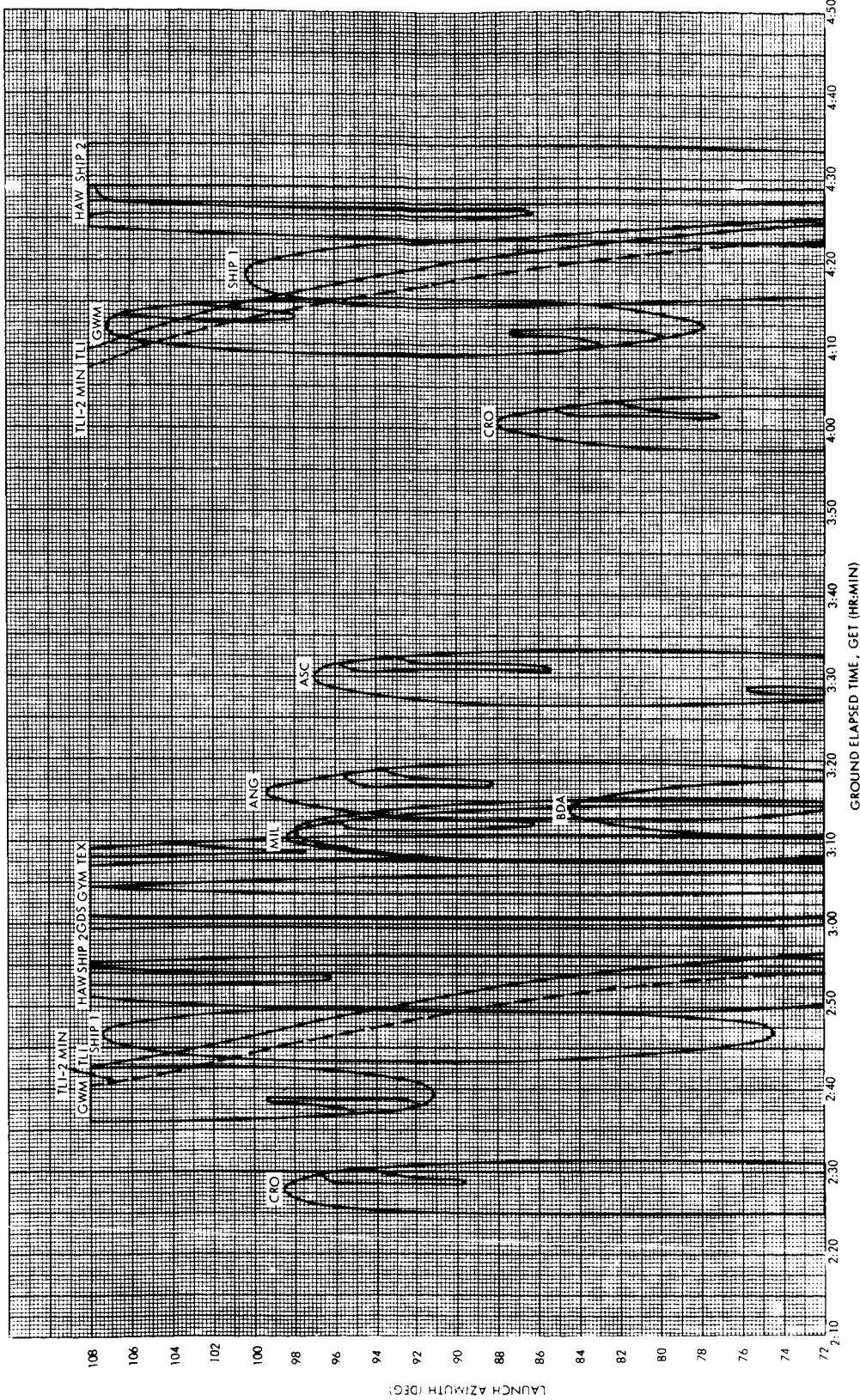


Figure 7a. MSFN and Injection Ships Visibility Contours, 0-degree Antenna Elevation,
September 13, 1969

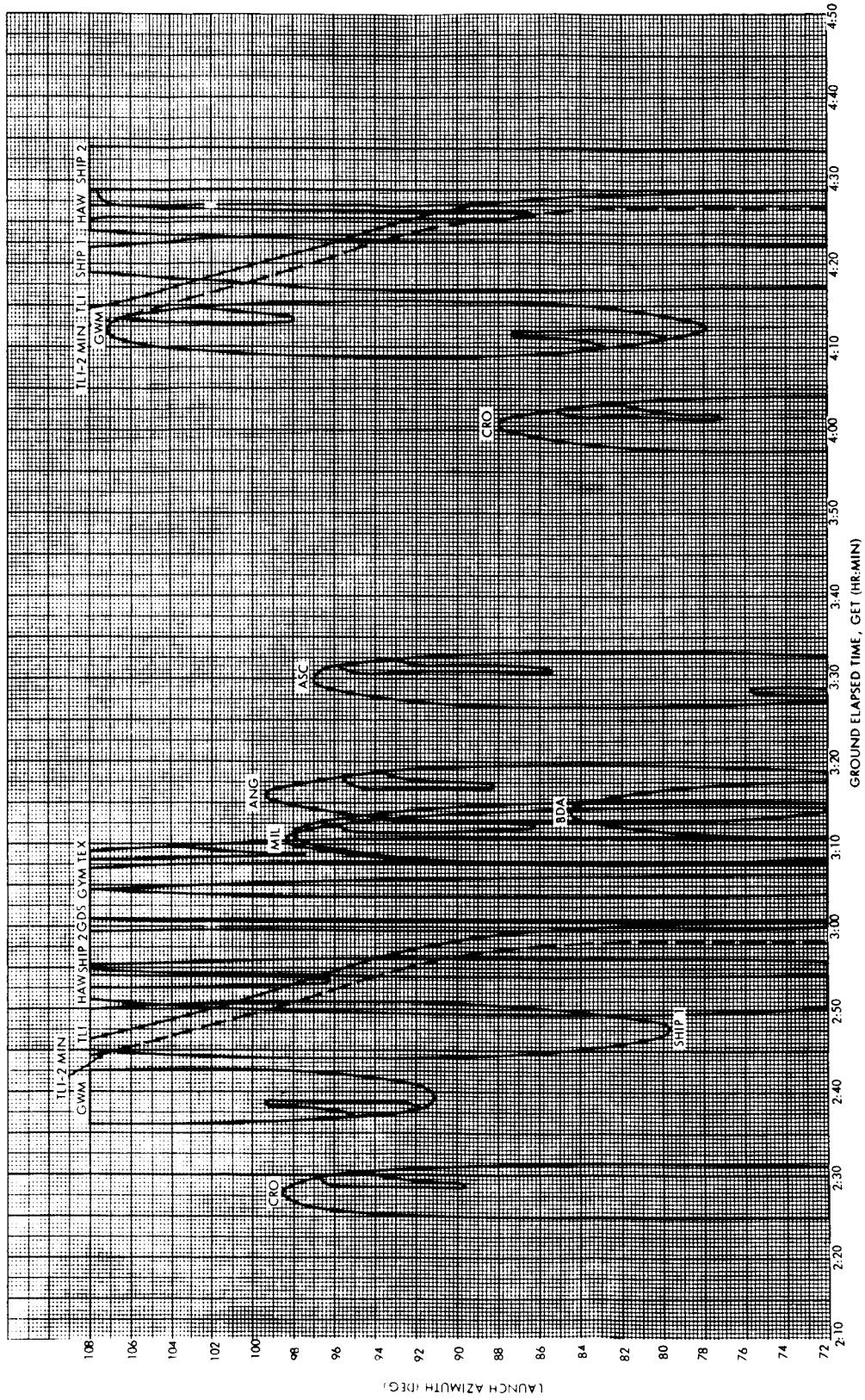


Figure 7b. MSF N and Injection Ships Visibility Contours, 0-degree Antenna Elevation,
September 15, 1969

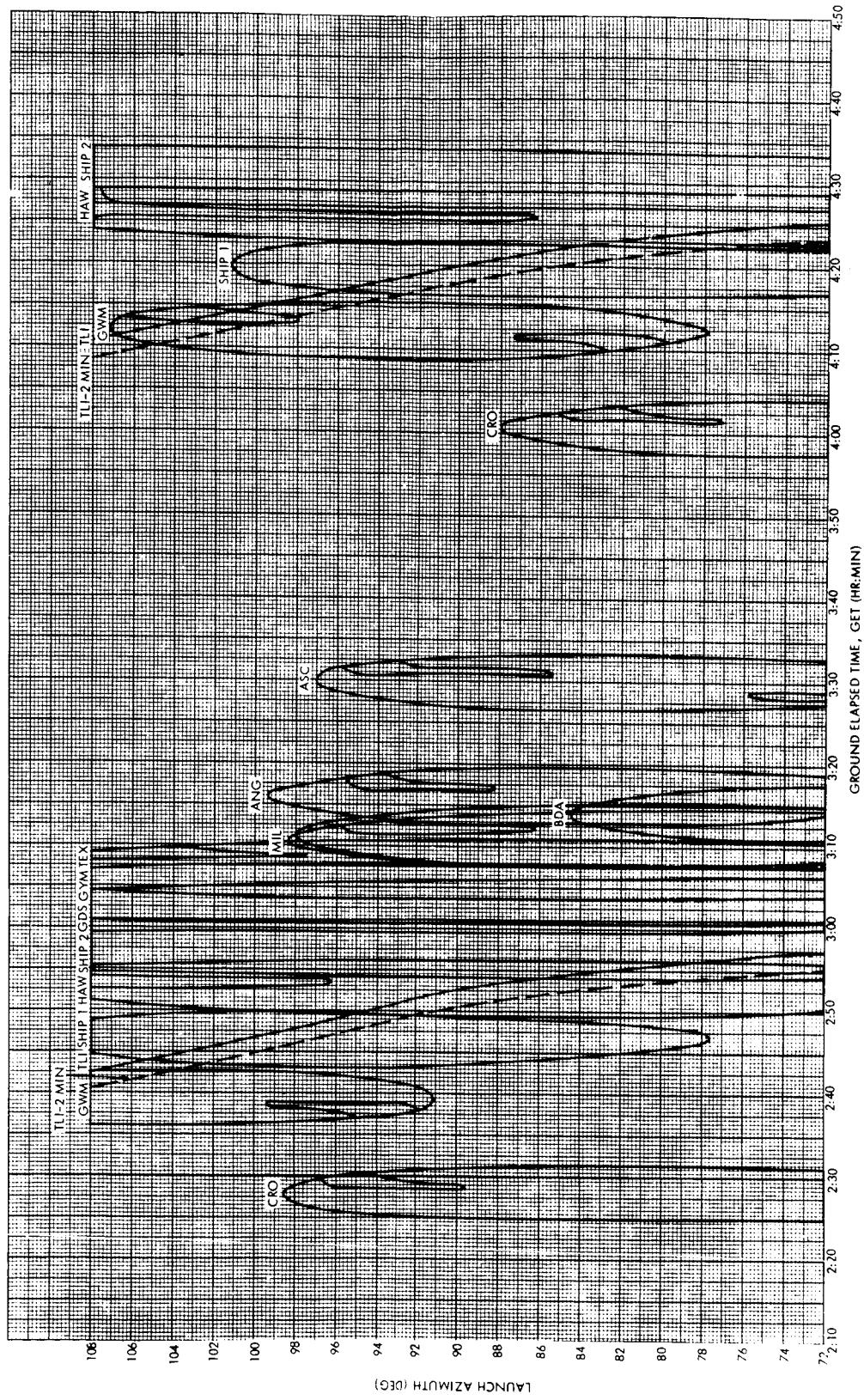


Figure 7c. MSFN and Injection Ships Visibility Contours, 0-degree Antenna Elevation,
September 18, 1969

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1. Dawley, R. E.: Injection Ship Positioning Technique for Apollo Lunar Missions. TRW Note 67-FMT-523, June 23, 1967.
2. Harrison, C. E. and White, J. R.: Preliminary Radar Ship Analysis Program. TRW Note 67-FMT-554, November 3, 1967.
3. Lakamp, L. L. and Hansen, R. H.: Geographic Loci of Apollo Translunar Injection Burns and Free Return Touchdown Positions, Volume VII. TRW Note 67-FMT-575, November 22, 1967.
4. Task Agreement for Mission Analysis Support for the Detailed Design of Lunar Missions. MSC/TRW Task A-134, Amendment 7, February 1, 1969.